

LEADFRAME, PLASTIC-ENCAPSULATED SEMICONDUCTOR DEVICE, AND METHOD FOR FABRICATING THE SAME

BACKGROUND OF THE INVENTION

- 5 The present invention relates to a plastic-encapsulated semiconductor device that is plastic-encapsulated at a portion thereof in which a semiconductor chip is mounted on a leadframe, and that exposes land electrodes each serving as an external terminal at the bottom surface of the device, and also relates to a leadframe used for the plastic-encapsulated semiconductor device.
- 10 In recent years, in order to cope with the downsizing of electronic equipment, high-density packaging of semiconductor components has been more and more required. In keeping with this trend, semiconductor devices are reduced not only in size but also in thickness. Furthermore, a variety of new ideas and new devices are being tested for the reduction of production cost and the improvement of productivity. Hereinafter, a 15 conventional leadframe used for a plastic-encapsulated semiconductor device, and how the leadframe is formed will be described.
- FIG. 12 shows the structure of a conventional leadframe used for a plastic-encapsulated semiconductor device disclosed in Japanese Unexamined Patent Publication No. 2001-77274. As shown in FIG. 12, the conventional leadframe includes:
- 20 a die pad 1001 on which a semiconductor chip is to be mounted; suspension leads 1003 each having a tail end which is connected to an outer frame 1002 and a front end at which an associated one of four corners of the die pad 1001 is supported; and linear land leads 1004 and leads 1005 each having a front end facing the die pad 1001 and a tail end connected to the outer frame 1002. As used herein, “suspension lead” refers to a lead that is suspended 25 between a die pad and an outer frame of a leadframe. The bottom portions of the land leads

1004 and leads **1005** each constitute an external terminal (land portion **1008**). Each lead **1005** is formed so that, in addition to the bottom portion thereof, an outer lateral portion thereof constitutes an external terminal to be connected to a motherboard. Besides, the front end of each land lead **1004** is extended beyond that of each lead **1005** and is located closer to
5 the die pad **1001**.

The die pad **1001** is provided with an upwardly protruding circular protrusion **1006** located at an approximate center of the surface of the die pad **1001**. The protrusion **1006** is formed by performing a pressing process in which a plate constituting the die pad **1001** is pressed so that the plate is half-sheared and is partially protruded upward. The protrusion
10 **1006** substantially functions as a portion for supporting a semiconductor chip, and when a semiconductor chip has been mounted thereon, a gap is formed between the top surface of the die pad **1001** (except a region thereof at which the protrusion **1006** is formed) and the bottom surface of the semiconductor chip. At a region of the top surface of the die pad **1001** surrounding the protrusion **1006**, a groove **1007** is provided. When a semiconductor chip,
15 which has been mounted on the die pad **1001**, is encapsulated with plastic encapsulant, the plastic encapsulant is allowed to get into the groove **1007**.

With the use of the leadframe formed as described above, a semiconductor chip is mounted on the die pad, connected to each lead with a metal wiring, and encapsulated with plastic encapsulant, thereby forming a plastic-encapsulated semiconductor device. In the
20 resulting device, the bottom surface of each land portion **1008** whose front end is curved is located at the bottom surface of the plastic-encapsulated semiconductor device, i.e., the bottom surface of the plastic package, and the bottom portion of each lead **1005** whose front end is curved is located outwardly of each land portion **1008** so that two rows of the external terminals are arranged in a zigzag manner. Thus, a Land Grid Array (LGA)
25 package is provided.

SUMMARY OF THE INVENTION

However, the conventional leadframe presents the following problems.

Although an LGA package in which a plurality of rows of the land portions are
5 arranged can be obtained by using the conventional leadframe, the land portions cannot be provided at a region of the leadframe where the suspension leads **1003** for fixing the die pad **1001** exist. Therefore, restrictions are imposed when the number of the land portions (terminal electrodes) is increased.

Further, when plastic encapsulation is carried out to form a semiconductor device
10 using the leadframe, warping of the semiconductor device occurs because the coefficients of thermal contraction of the die pad and the plastic encapsulant are different due to the existence of the suspension leads.

Furthermore, the number of process steps carried out before a sheet is affixed is increased, which contributes to an increase in the cost.

15 Therefore, with an eye to forming more various semiconductor devices and more numerous terminals in each semiconductor device, the object of the present invention is to provide a leadframe suitably used in fabricating a high-quality plastic-encapsulated semiconductor device with a high productivity at a low cost, a plastic-encapsulated semiconductor device formed using such a leadframe, and a method for fabricating the
20 device.

A first inventive leadframe includes: an outer frame; a die pad; and a plurality of leads each having land portions and connections. The land portions each have an upper surface serving as a bonding pad and a lowermost part serving as an external terminal, and the connections are provided between the outer frame and the land portions, between the
25 land portions associated with each other in each lead, and between the land portions and

the die pad. In addition, in the first inventive leadframe, there exists no lead that functions as a suspension lead during plastic encapsulation.

Thus, the external terminals can be provided instead of suspension leads that have normally been provided in the corners of the die pad, and therefore, it becomes possible to
5 obtain a plastic-encapsulated semiconductor device in which the external terminals are provided at a high density. Further, it becomes possible to suppress, for example, deformation and displacement of the die pad which are likely to occur due to the existence of the suspension leads.

In one embodiment of the first inventive leadframe, the lowermost parts of the
10 land portions may be substantially identical in shape in plan view and may be arranged in a lattice pattern. In such an embodiment, a higher density packaging can be achieved.

In another embodiment of the first inventive leadframe, three or more rows of the lowermost parts of the land portions are preferably arranged along each side of the outer frame.

15 A second inventive leadframe includes: an outer frame; a die pad having a thin portion that is provided along the peripheral section of the die pad and that is devoid of its lower part, and having heat dissipating terminals protruded downward from the lower surface of the thin portion; and a plurality of leads each having land portions and connections. The land portions each have an upper surface serving as a bonding pad and
20 a lowermost part serving as an external terminal, and the connections are provided between the outer frame and the land portions, between the land portions associated with each other in each lead, and between the land portions and the heat dissipating terminals.

Thus, when a plastic-encapsulated semiconductor device that has been formed using the leadframe is mounted on a motherboard, the external terminals and the heat
25 dissipating terminals can be connected to, for example, electrodes of the motherboard by a

ass reflow soldering process, thus carrying out the packaging more stably and easily.

In one embodiment of the second inventive leadframe, the land portions and the heat dissipating terminals may be substantially identical in shape in plan view and may be arranged in a lattice pattern. In such an embodiment, a higher density packaging can be
5 achieved.

In another embodiment of the second inventive leadframe, the land portions and the heat dissipating terminals are preferably arranged at substantially fixed pitch intervals in at least one direction. In still another embodiment, three or more rows of the land portions are preferably arranged along each side of the outer frame.

10 A first inventive plastic-encapsulated semiconductor device is one that is formed using the first inventive leadframe. More specifically, the first inventive plastic-encapsulated semiconductor device includes: a die pad; a semiconductor chip; land portions each having an upper surface serving as a bonding pad to be connected with a metal wiring and a lowermost part serving as an external terminal; and a plastic
15 encapsulant for encapsulating the semiconductor chip, land portions, die pad and so on, with the lowermost parts of the land portions and at least a part of the bottom surface of the die pad exposed, wherein the semiconductor device is provided with no member that extends from the die pad and that has its end exposed at a surface of the plastic encapsulant.

20 Thus, the external terminals can be provided instead of the suspension leads that have normally been provided in the corners of the die pad, and therefore, it becomes possible to obtain a plastic-encapsulated semiconductor device in which the external terminals are provided at a high density.

In one embodiment of the first inventive plastic-encapsulated semiconductor device,
25 the external terminals may be substantially identical in shape in plan view and may be

arranged in a lattice pattern at the bottom surface of the plastic encapsulant. In such an embodiment, a higher density packaging can be achieved.

In another embodiment of the first inventive plastic-encapsulated semiconductor device, three or more rows of the external terminals are preferably arranged at the bottom 5 surface of the plastic encapsulant along the peripheral region thereof.

A second inventive plastic-encapsulated semiconductor device is one that is formed using the second inventive leadframe. More specifically, the second inventive plastic-encapsulated semiconductor device includes: a die pad having a thin portion that is provided along the peripheral section of the main body of the die pad and that is devoid of 10 its lower part, and a plurality of heat dissipating terminals provided so as to protrude downward from the lower surface of the thin portion; a semiconductor chip; land portions each having an upper surface serving as a bonding pad to be connected with a metal wiring and a lowermost part serving as an external terminal; and a plastic encapsulant for 15 encapsulating the semiconductor chip, land portions, leads, die pad and so on, with the lowermost parts of the land portions and the lowermost parts of the heat dissipating terminals exposed.

Thus, when the plastic-encapsulated semiconductor device is mounted on a motherboard, the external terminals and the heat dissipating terminals can be connected to, for example, electrodes of the motherboard by a mass reflow soldering process, thus 20 carrying out the packaging more stably and easily

In one embodiment of the second inventive plastic-encapsulated semiconductor device, the external terminals and the heat dissipating terminals may be substantially identical in shape in plan view and may be arranged in a lattice pattern at the bottom surface of the plastic encapsulant. In such an embodiment, the packaging can be carried 25 out more easily at a high density.

In another embodiment of the second inventive plastic-encapsulated semiconductor device, the external terminals and the heat dissipating terminals are preferably arranged at substantially fixed pitch intervals in at least one direction. In still another embodiment, three or more rows of the external terminals are preferably arranged

5 at the bottom surface of the plastic encapsulant along the peripheral region thereof.

In a first inventive method for fabricating a plastic-encapsulated semiconductor device, after the first inventive leadframe has been prepared, a die bonding step is carried out, the connections of the leadframe placed on a sheet for encapsulation are cut, electrical connection is provided, and then plastic encapsulation is carried out with the encapsulation

10 sheet affixed to the leadframe.

Thus, even if no suspension leads are provided, the electrical connection and plastic encapsulation can be provided while the positions of the die pad and the land portions are stabilized, thereby obtaining the plastic-encapsulated semiconductor device in which the external terminals are provided at a high density.

15 In a second inventive method for fabricating a plastic-encapsulated semiconductor device, after the second inventive leadframe has been prepared, a die bonding step is carried out, the connections of the leadframe placed on a sheet for encapsulation are cut, electrical connection is provided, and then plastic encapsulation is carried out with the encapsulation sheet affixed to the leadframe.

20 Thus, the electrical connection and plastic encapsulation can be provided while the positions of the die pad and the land portions are stabilized, and the heat dissipating terminals and external terminals can be aligned together so as to be protruded from the bottom surface of the plastic encapsulant, thereby obtaining the plastic-encapsulated semiconductor device that can be easily packaged on a motherboard.

25 In the first inventive leadframe, the plastic-encapsulated semiconductor device

formed using the leadframe, and the method for fabricating the semiconductor device, no suspension leads are provided, and thus the external terminals can be provided at a high density accordingly in the resulting plastic-encapsulated semiconductor device.

In the second inventive leadframe, the plastic-encapsulated semiconductor device
5 formed using the leadframe, and the method for fabricating the semiconductor device, the die pad is provided with the heat dissipating terminals that are arranged along with the external terminals, and thus the packaging can be more easily carried out.

BRIEF DESCRIPTION OF THE DRAWINGS

10 FIGS. 1A and 1B are a plan view of a leadframe according to a first embodiment of the present invention, and a cross-sectional view taken along the line IIB-IIB shown in FIG. 1A, respectively.

FIGS. 2A and 2B are a plan view illustrating the step of upsetting the center of a die pad which is included in the fabrication process of a plastic-encapsulated semiconductor
15 device of the first embodiment, and a cross-sectional view taken along the line IIIB-IIIB shown in FIG. 2A, respectively.

FIGS. 3A and 3B are a plan view illustrating the step of placing the leadframe on a sheet for encapsulation which is included in the fabrication process of the plastic-encapsulated semiconductor device of the first embodiment, and a cross-sectional view taken along the line
20 IIIIB-IIIIB shown in FIG. 3A, respectively.

FIGS. 4A and 4B are a plan view illustrating the step of dividing leads which is included in the fabrication process of the plastic-encapsulated semiconductor device of the first embodiment, and a cross-sectional view taken along the line IVB-IVB shown in FIG. 4A, respectively.

25 FIG. 5 is a partial cross-sectional view illustrating the step of carrying out plastic

encapsulation which is included in the fabrication process of the plastic-encapsulated semiconductor device of the first embodiment.

FIGS. 6A and 6B are a cross-sectional view, which is taken along the line VIA-VIA, for illustrating the structure of the plastic-encapsulated semiconductor device of the first embodiment after the plastic encapsulation step has been completed, and a bottom view of the semiconductor device, respectively.

FIGS. 7A and 7B are a plan view of a leadframe according to a second embodiment of the present invention, and a cross-sectional view taken along the line VIIIB-VIIIB shown in FIG. 7A, respectively.

FIGS. 8A and 8B are a plan view illustrating the step of upsetting the center of a die pad and placing the leadframe on a sheet for encapsulation which is included in the fabrication process of the plastic-encapsulated semiconductor device of the second embodiment, and a cross-sectional view taken along the line VIIIB-VIIIB shown in FIG. 8A, respectively.

FIGS. 9A and 9B are a plan view illustrating the step of dividing leads which is included in the fabrication process of the plastic-encapsulated semiconductor device of the second embodiment, and a cross-sectional view taken along the line IXB-IXB shown in FIG. 9A, respectively.

FIGS. 10A and 10B are a cross-sectional view, which is taken along the line XA-XA, for illustrating the structure of the plastic-encapsulated semiconductor device of the second embodiment after plastic encapsulation has been completed, and a bottom view of the semiconductor device, respectively.

FIGS. 11A and 11B are a plan view of a leadframe according to a modified example of the second embodiment of the present invention, and a cross-sectional view taken along the line XIIB-XIIB shown in FIG. 11A, respectively.

FIG. 12 shows the structure of a conventional leadframe used for a plastic-encapsulated semiconductor device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

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<First Embodiment>

-Structure of Leadframe-

FIGS. 1A and 1B are a plan view of a leadframe (leadframe **LF1**) according to a first embodiment of the present invention, and a cross-sectional view taken along the line **IB-IB** shown in FIG. 1A, respectively. Actually, in the leadframe **LF1**, regions thereof on which a large number of semiconductor chips are to be mounted are laid out continuously in a grid pattern; however, FIG. 1A only shows a part of the leadframe **LF1**, i.e., a region thereof on which a single semiconductor chip is to be mounted. The leadframe **LF1** is obtained by, for example, etching or stamping a copper alloy plate.

As shown in FIGS. 1A and 1B, the leadframe **LF1** according to the present embodiment includes: a rectangular outer frame **100** including four sides that surround a region of the leadframe **LF1** on which a semiconductor chip is to be mounted (which region will be hereinafter called a “chip mounting region **Rtp**”); a die pad **101** which is provided at the center of the chip mounting region **Rtp** and on which a semiconductor chip is to be mounted; leads **102** each extending from the outer frame **100** to connect with the die pad **101**; and reinforcing lands **103**.

The leads **102** of the present embodiment each include land portions **104** and connections **105** which are alternately arranged. The land portions **104** each have a width of 20 μ m to 120 μ m, for example, and a thickness of 20 μ m to 120 μ m, for example, and the connections **105** each have a width of 15 μ m to 100 μ m, for example, and a thickness of 15 μ m

to 100 μ m, for example. That is, each land portion 104 is wider and thicker than each connection 105. The upper surface of each land portion 104 functions as a bonding pad 104a to be connected with a metal wiring. In the step of packaging a semiconductor chip on the leadframe LF1, plastic encapsulation is carried out with the lower surface of each land 5 portion 104 fixed onto a sheet for encapsulation which has an adhesive layer, and after the plastic encapsulation has been completed, the lowermost part of each land portion 104 is allowed to function as a land electrode 104b (external terminal) that is protruded downward from the bottom surface of the plastic encapsulant. Via the connections 105, the outer frame 100 and the land portions 104 are connected to each other, the land portions 104 associated 10 with each other in each lead 102 are connected to each other, and the land portions 104 and the die pad 101 are connected to each other. Each connection 105 is allowed to be devoid of its lower part by a pressing process utilizing a die or by an etching process, and is embedded within the plastic encapsulant in the step of packaging a semiconductor chip on the leadframe LF1. The connection 105 are each continuous with the upper part of each land 15 portion 104, and the upper surface of each connection 105 and that of each land portion 104 constitute a common plane.

The features of the leadframe LF1 according to the present embodiment will be described below. In the leadframe LF1 of the present embodiment, there exists no member that has been provided in a normal leadframe and that merely functions as a suspension lead. 20 In other words, every lead is provided with the land portion 104 in the present embodiment. Therefore, the die pad of the leadframe LF1 of the present embodiment is not connected to the outer frame during the step of carrying out plastic encapsulation, and there is provided no lead that functions as a suspension lead during this step. That is, in the plastic-encapsulated semiconductor device formed using the lead frame LF1, there exists no lead that is 25 extended from the die pad 101 and is exposed at the surface of the plastic encapsulant.

In the leadframe **LF1** of the present embodiment, the land portions **104** (i.e., the bonding pads **104a** and land electrodes **104b**) are also provided on lines that connect the corners of the die pad **101** and outer frame **100** together. Further, in the leadframe **LF1** of the present embodiment, there exist leads **102x** (or **102y**) each having one end that is
5 connected to one side of the outer frame **100** and the other end that is connected, in the vicinity of the associated corner, to other lead **102y** (or **102x**) extending from the other side of the outer frame **100** adjacent to the one side thereof. In other words, there exist the leads **102x** (or **102y**) that are connected to the die pad **101** via the other leads **102y** (or **102x**). Furthermore, the leadframe **LF1** of the present embodiment is provided with the reinforcing
10 lands **103** each directly connected to the outer frame **100** in the vicinity of the corner thereof and having an area (e.g., a diameter of 300 μm to 1500 μm) considerably larger than that of each land portion **104**.

The land electrodes (external terminals) **104b**, which are the lowermost parts of the land portions **104**, are substantially identical in shape in plan view, and are arranged in a
15 lattice pattern. In this case, “substantially identical” means that they are identical when variations caused during fabrication are not taken into consideration.

In the leadframe **LF1** of the present embodiment, in the vicinities of the corners of the die pad **101** and outer frame **100**, no suspension leads are provided but the leads extending from adjacent two sides of the outer frame **100** are connected to each other, thus making it
20 possible to form a plastic-encapsulated semiconductor device in which a plurality of rows of the land electrodes **104b** (external terminals) are provided along each side of the outer frame **100** including the vicinities of the corners of the die pad **101**. If suspension leads exist in the corners of the die pad and outer frame as in the conventional leadframe, a land electrode can be provided in a part of each suspension lead. In that case, however, each suspension lead is
25 connected to the die pad, and therefore, the land electrode provided in a part of each

suspension lead is only used as a simple reinforcing one or as a terminal (e.g., a ground terminal) whose potential is equal to that of the die pad. On the other hand, in the leadframe **LF1** of the present embodiment, the land electrodes each functioning as a signal terminal can also be provided in the vicinity of each corner of the die pad **101**, and thus the land electrodes 5 can be provided at a high density. In other words, restrictions on the location and the number of the land electrodes can be relaxed.

Further, as will be described later, in the step of carrying out plastic encapsulation using the leadframe **LF1** of the present embodiment, each land electrode **104b** (land portion **104**) and the die pad **101** are spaced apart and disconnected from each other, and are 10 supported on a sheet for encapsulation in this state. Thus, it becomes possible to disperse the warping of the semiconductor device, which occurs due to a difference between the thermal contraction coefficient of the leadframe main body and that of the plastic encapsulant, and therefore, the amount of warping of the overall semiconductor device can be reduced.

In the leadframe **LF1** of the present embodiment, the reinforcing lands **103**, each 15 having a large circular pattern, are provided in the corners of the outer frame **100**. Therefore, when the plastic-encapsulated semiconductor device is packaged on a motherboard (i.e., when a secondary packaging is carried out), the strength of the connection between the plastic-encapsulated semiconductor device and the motherboard, which is provided by solder or the like, can be increased.

20 However, the reinforcing lands **103** do not necessarily have to be provided in the leadframe **LF1** of the present embodiment. If the reinforcing lands **103** do not exist, the land electrodes (land portions) can be provided in the space made available by providing no reinforcing lands **103**, and thus the land electrodes can be provided at a higher density.

Described below is an exemplary fabrication process of a plastic-encapsulated semiconductor device in which the leadframe **LF1** of the present embodiment is used. FIGS. 2A and 2B are a plan view illustrating the step of upsetting the center of the die pad which is included in the fabrication process of the plastic-encapsulated semiconductor device of the first embodiment, and a cross-sectional view taken along the line IIB-IIB shown in FIG. 2A, respectively. FIGS. 3A and 3B are a plan view illustrating the step of placing the leadframe on a sheet for encapsulation which is included in the fabrication process of the plastic-encapsulated semiconductor device of the first embodiment, and a cross-sectional view taken along the line IIIB-IIIIB shown in FIG. 3A, respectively. FIGS. 4A and 4B are a plan view illustrating the step of dividing the leads which is included in the fabrication process of the plastic-encapsulated semiconductor device of the first embodiment, and a cross-sectional view taken along the line IVB-IVB shown in FIG. 4A, respectively. FIG. 5 is a partial cross-sectional view illustrating the step of carrying out plastic encapsulation which is included in the fabrication process of the plastic-encapsulated semiconductor device of the first embodiment. And FIGS. 6A and 6B are a cross-sectional view, which is taken along the line VIA-VIA, for illustrating the structure of the plastic-encapsulated semiconductor device of the first embodiment after the plastic encapsulation step has been completed, and a bottom view of the semiconductor device, respectively.

First, in the step shown in FIGS. 2A and 2B, a metal plate made of an alloy whose major constituent is copper (Cu) or made of an iron (Fe) and nickel (Ni) alloy is integrally molded by stamping or etching, and the leadframe **LF1** having the structure shown in FIGS. 1A and 1B is prepared. Next, the leadframe **LF1** is subjected to a pressing process by utilizing an upper die for half-shearing and a lower die for pressing (both the dies are not shown), thereby forming a circular protrusion **101a** on the die pad **101**. Although this step is carried out in order to upset a semiconductor chip and support it on the die pad **101**, the

protrusion **101a** does not necessarily have to be provided. Furthermore, the leadframe **LF1** is partially or entirely subjected to plating that is required for the connection of the leadframe **LF1** with the semiconductor chip or the packaging thereof. The leadframe **LF1** may be given Ag plating, Au plating, Ni-Pd-Au plating or the like.

5 Next, in the step shown in FIGS. **3A** and **3B**, an encapsulation sheet **150** is affixed to the bottom surface of the leadframe **LF1**, i.e., the lower surfaces of the main body of the die pad **101**, reinforcing lands **103** and land portions **104**, so that the encapsulation sheet **150** is brought into intimate contact with these lower surfaces. Provided at the upper surface of the encapsulation sheet **150** is an adhesive layer, and via this adhesive layer, the die pad **101**, the 10 reinforcing lands **103** and the land portions **104** of the leads **102** are isolatedly fixed onto the encapsulation sheet **150**.

Then, in the step shown in FIGS. **4A** and **4B**, the leads **102** are divided into cut portions **Ct1**, **Ct2** and **Ct3** by carrying out a pressing process using a die with the leadframe **LF1** fixed on the encapsulation sheet **150**. That is, the leads **102** are cut at the connections 15 **105** between the land portions **104** and the die pad **101**, at the connections **105** between the land portions **104** associated with each other in each lead **102**, and at the connections between the land portions **104** and the outer frame **100**, thus isolating the die pad **101** and each land portion **104**.

Subsequently, although not shown, a die bonding step and a wire bonding step are 20 carried out. In the die bonding step, a semiconductor chip **160** is mounted on the die pad **101** in each chip mounting region **Rtp** of the leadframe **LF1** that is placed onto the encapsulation sheet **150**, and in the wire bonding step, pad electrodes of the semiconductor chip **160** and the bonding pads **104a** of the land portions **104** are connected to each other with metal wirings **170** each serving as a connecting member.

25 Then, as shown in FIG. **5**, the leadframe **LF1** is set in a die for encapsulation which

includes an upper die member 180a and a lower die member 180b and has a die cavity therebetween. Specifically, the leadframe LF1 is set in the encapsulation die so that the semiconductor chip 160, the metal wirings 170 and so on are located within the die cavity, and the die cavity is filled with plastic encapsulant with the upper and lower die members 180a and 180b pressed towards each other.

5 After the plastic encapsulation step has been completed, the encapsulation sheet 150 is removed from the leadframe LF1 and the plastic encapsulant, and then a large number of plastic-encapsulated semiconductor devices provided on the leadframe LF1 are each cut out, thus obtaining the plastic-encapsulated semiconductor devices each having the structure 10 shown in FIGS. 6A and 6B. It is to be noted that in the cross section shown in FIG. 6A, the transverse size of the right half is scaled down so as to correspond to that of the left half.

As shown in FIGS. 6A and 6B, each land electrode 104b, which is the lowermost part of each land portion 104 of the leadframe LF1, the lowermost part of the die pad 101 and the lowermost part of each reinforcing land 103 are protruded downward from plastic 15 encapsulant 190. In particular, it can be seen that a plurality of rows of the land electrodes 104b are arranged at fixed pitch intervals (spacing) P1 in the longitudinal and transverse directions in FIG. 6B, and that the land electrodes 104b are arranged also in the vicinity of each corner. In the resulting plastic-encapsulated semiconductor device, there exists no lead that is extended from the die pad 101 and is exposed at the surface of the plastic encapsulant.

20 The spacing between the land electrodes 104b does not necessarily have to be fixed, and even if they are arranged at fixed pitch intervals, the pitch between the land electrodes 104b in the longitudinal direction in FIG. 6B may be different from the pitch between the land electrodes 104b in the transverse direction in FIG. 6B. However, if the land electrodes 104b are arranged at fixed pitch intervals in this way, the plastic-encapsulated semiconductor 25 device compliant with the standards of the actual semiconductor device can be obtained.

In the plastic-encapsulated semiconductor device of the present embodiment, there exist no suspension leads that have conventionally been provided, and furthermore, the connections **105**, which are narrower and thinner than the land portions **104**, are provided between the die pad **101** and the land portions **104** of the leads **102**, between the land portions **104** associated with each other in each lead **102**, and between the land portions **104** and the outer frame **100**. Therefore, in the step shown in FIGS. **4A** and **4B**, the leads **102** can be easily cut between the land portions **104** associated with each other in each lead **102** and between the land portions **104** and the outer frame **100** with the semiconductor chip **160** mounted on the leadframe **LF1**, and the wire bonding step and/or the plastic encapsulation step can be carried out with no connecting members provided between the die pad **101** and the outer frame **100**.

Accordingly, the fabricators can be saved from having to carry out etching, stamping or the like for the formation of the suspension leads, and it becomes possible to obtain the plastic-encapsulated semiconductor device in which the land electrodes **104b** are provided at a high density as shown in FIGS. **6A** and **6B**.

<Second Embodiment>

FIGS. **7A** and **7B** are a plan view of a leadframe (leadframe **LF2**) according to a second embodiment of the present invention, and a cross-sectional view taken along the line **VIIIB-VIIB** shown in FIG. **7A**, respectively. Actually, in the leadframe **LF2**, regions thereof on which a large number of semiconductor chips are to be mounted are laid out continuously in a grid pattern; however, FIG. **7A** only shows a part of the leadframe **LF2**, i.e., a region thereof on which a single semiconductor chip is to be mounted. The leadframe **LF2** is obtained by, for example, etching or stamping a copper alloy plate.

As shown in FIGS. **7A** and **7B**, the leadframe **LF2** according to the present

embodiment includes: a rectangular outer frame 200 including four sides that surround a chip mounting region Rtp; a die pad 201 which is provided at the center of the chip mounting region Rtp and on which a semiconductor chip is to be mounted; leads 202 each extending from the outer frame 200 to connect with the die pad 201; reinforcing lands 203; and heat dissipating terminals 201b that are provided at the peripheral section of the die pad 201 and are connected to the leads 202.

The leads 202 of the present embodiment each include land portions 204 and connections 205 which are alternately arranged. The land portions 204 each have a width of 20 μ m to 120 μ m, for example, and a thickness of 20 μ m to 120 μ m, for example, and the connections 205 each have a width of 15 μ m to 100 μ m, for example, and a thickness of 15 μ m to 100 μ m, for example. That is, each land portion 204 is wider and thicker than each connection 205. The upper surface of each land portion 204 functions as a bonding pad 204a to be connected with a metal wiring. In the step of packaging a semiconductor chip on the leadframe LF2, plastic encapsulation is carried out with the lower surface of each land portion 204 fixed onto an encapsulation sheet that has an adhesive layer, and after the plastic encapsulation has been completed, the lowermost part of each land portion 204 is allowed to function as a land electrode 204b that is protruded downward from the bottom surface of the plastic encapsulant. Via the connections 205, the outer frame 200 and the land portions 204 are connected to each other, the land portions 204 associated with each other in each lead 202 are connected to each other, and the land portions 204 and the heat dissipating terminals 201b of the die pad 201 are connected to each other. Each connection 205 is allowed to be devoid of its lower part by a pressing process utilizing a die or by an etching process, and is embedded within the plastic encapsulant in the step of packaging a semiconductor chip on the leadframe LF2. The connections 205 are each continuous with the upper part of each land portion 204, and the upper surface of each connection 205 and that of each land portion

204 constitute a common plane.

The features of the leadframe **LF2** according to the present embodiment will be described below. In the leadframe **LF2** of the present embodiment, there exists no suspension lead that has been provided in a normal leadframe and that only has the function 5 of supporting the die pad. Furthermore, since the leads **202**, through which the die pad **201** of the leadframe **LF2** of the present embodiment is connected to the outer frame **200**, are divided, the die pad **201** is disconnected from the outer frame **200** during the step of carrying out plastic encapsulation, and there is provided no lead that functions as a suspension lead during this step. In the leadframe **LF2** of the present embodiment, the land portions **204** 10 (i.e., the bonding pads **204a** and land electrodes **204b**) are also provided on lines that connect the corners of the die pad **201** and outer frame **200** together. Besides, in the leadframe **LF2** of the present embodiment, there exist leads **202x** (or **202y**) each having one end that is connected to one side of the outer frame **200** and the other end that is not directly connected to the die pad **201** but connected, in the vicinity of the associated corner, to other lead **202y** 15 (or **202x**) extending from the other side of the outer frame **200** adjacent to the one side thereof. In other words, there exist the leads **202x** (or **202y**) that extend from one side of the outer frame **200** and that are connected to the die pad **201** via the other leads **202y** (or **202x**) extending from the other side of the outer frame **200** adjacent to the one side thereof. Furthermore, in the vicinities of the corners of the outer frame **200**, the leadframe **LF2** of the 20 present embodiment is provided with the reinforcing lands **203** each having an area (e.g., a diameter of 300 μm to 1500 μm) considerably larger than that of each land portion **204**.

In addition to the features of the leadframe **LF1** of the first embodiment, the leadframe **LF2** of the second embodiment further has the following feature. The peripheral section of the die pad **201** is devoid of its lower part so as to form a thin portion **201c**, and the 25 heat dissipating terminals **201b** are provided at the thin portion **201c** so as to protrude

downward from the lower surface thereof. The heat dissipating terminals **201b** are each formed into such a shape by carrying out a half-etching or pressing process so that the peripheral section of the die pad **201** is devoid of its lower part while portions thereof to be used as the heat dissipating terminals **201b** are left.

5 In the present embodiment, the land electrodes (external terminals) **204b**, which are the lowermost parts of the land portions **204**, and the lowermost parts of the heat dissipating terminals **201b** are substantially identical in shape in plan view, and are arranged in a lattice pattern. In this case, “substantially identical” means that they are identical when variations caused during fabrication are not taken into consideration. However, the land electrodes
10 (external terminals) **204b**, i.e., the lowermost parts of the land portions **204**, and the lowermost parts of the heat dissipating terminals **201b** do not necessarily have to be substantially identical in shape in plan view. Even if these lowermost parts are not substantially identical in shape in plan view, the after-mentioned basic effects can be achieved.

15 Since the heat dissipating terminals **201b** are provided, the leadframe **LF2** of the present embodiment can achieve, in addition to the effects of the first embodiment, the following exceptional effects.

 Suppose that a plastic-encapsulated semiconductor device with a Land Grid Array (LGA) structure is fabricated using the leadframe **LF1** of the first embodiment. In that case,
20 when the leads **102** are cut between the land portions **104** and the die pad **101** by a stamping process, the leads **102** might be deformed after they have been cut. Therefore, to avoid such a problem, it is required that the connections **105** between the land portions **104** and the die pad **101** be longer than the connections **105** between the land portions **104** associated with each other in each lead **102**, as shown in FIGS. **1A** and **1B**. However, in the future, as the
25 number of the land electrodes will be increased, the shape of the leads after stamping is

expected to increase in complexity, which will be more likely to cause deformation and might reduce productivity.

If the die pad **201** is provided with the heat dissipating terminals **201b** as in the second embodiment, the land portions **204** and die pad **201** can be smoothly detached from the outer frame **200** while the deformation of the leads **202** is being suppressed in the after-mentioned step of cutting the leads **202**. As a result, the connections **205** for connecting the land portions **204** at the extreme ends of the leads **202** to the heat dissipating terminals **201b** can be reduced in length, and thus the land portions **204** (and the land electrodes **204b**) can be provided at a higher density.

Due to the existence of the heat dissipating terminals **201b**, when the after-mentioned plastic-encapsulated semiconductor device is packaged on a motherboard, only the heat dissipating terminals **201b** and land electrodes **204b** can be connected to, for example, electrodes of the motherboard by a mass reflow soldering process without connecting the main body of the die pad **201**, which is likely to cause connection failure, to the motherboard. Even if the main body of the die pad **201** is not connected to the motherboard, the heat generated in the semiconductor chip is allowed to quickly dissipate to the motherboard through the heat dissipating terminals **201b**. The present embodiment is provided in view of the fact that heat dissipating function is saturated if the area of heat dissipation exceeds a certain level, and therefore, the total area of the lower surfaces of the plurality of heat dissipating terminals **201b** is set so that the heat generated in the semiconductor chip is quickly dissipated to the motherboard and the function of each semiconductor element provided on the semiconductor chip is not degraded. Accordingly, the heat dissipating function of the plastic-encapsulated semiconductor device, in which the leadframe of the second embodiment is used, can be maintained at the substantially same level as that of the plastic-encapsulated semiconductor device of the first embodiment.

-Fabrication Process of Plastic-Encapsulated Semiconductor Device-

Described below is an exemplary fabrication process of a plastic-encapsulated semiconductor device in which the leadframe **LF2** of the present embodiment is used. FIGS. 5 **8A** and **8B** are a plan view illustrating the step of upsetting the center of the die pad and placing the leadframe on an encapsulation sheet which is included in the fabrication process of the plastic-encapsulated semiconductor device of the second embodiment, and a cross-sectional view taken along the line **VIIIB-VIIIB** shown in FIG. **8A**, respectively. FIGS. **9A** and **9B** are a plan view illustrating the step of dividing the leads which is included 10 in the fabrication process of the plastic-encapsulated semiconductor device of the second embodiment, and a cross-sectional view taken along the line **IXB-IXB** shown in FIG. **9A**, respectively. And FIGS. **10A** and **10B** are a cross-sectional view, which is taken along the line **XA-XA**, for illustrating the structure of the plastic-encapsulated semiconductor device of the second embodiment after plastic encapsulation has been completed, and a bottom view of 15 the semiconductor device, respectively.

First, in the step shown in FIGS. **8A** and **8B**, a metal plate made of an alloy whose major constituent is copper (Cu) or made of an iron (Fe) and nickel (Ni) alloy is integrally molded by stamping or etching, and the leadframe **LF2** having the structure shown in FIGS. 20 **7A** and **7B** is prepared. Next, the leadframe **LF2** is subjected to a pressing process by utilizing an upper die for half-shearing and a lower die for pressing (both the dies are not shown), thereby forming a circular protrusion **201a** on the die pad **201**. Although this step is carried out in order to upset a semiconductor chip and support it on the die pad **201**, the protrusion **201a** does not necessarily have to be provided. Furthermore, the leadframe **LF2** is partially or entirely subjected to plating that is required for the connection of the leadframe 25 **LF2** with the semiconductor chip or the packaging thereof. The leadframe **LF2** may be

given Ag plating, Au plating, Ni-Pd-Au plating or the like.

Next, an encapsulation sheet 250 is affixed to the bottom surface of the leadframe **LF2**, i.e., the lower surfaces of the die pad 201, reinforcing lands 203 and land portions 204, so that the encapsulation sheet 250 is brought into intimate contact with these lower surfaces.

- 5 Provided at the upper surface of the encapsulation sheet 250 is an adhesive layer, and via this adhesive layer, the main body of the die pad 201, the heat dissipating terminals 201b of the die pad 201, the reinforcing lands 203 and the land portions 204 of the leads 202 are isolatedly fixed onto the encapsulation sheet 250.

Then, in the step shown in FIGS. 9A and 9B, the leads 202 are cut at the connections 10 205 by carrying out a pressing process using a die with the leadframe **LF2** fixed onto the encapsulation sheet 250. In this step, the leads 202 are cut at the connections 205 between the land portions 204 of the leads 202 and the heat dissipating terminals 201b of the die pad 201, at the connections 205 between the land portions 204 associated with each other in each lead 202, and at the connections 205 between the land portions 204 and the outer frame 200 15 so that the die pad 201 and each land portion 204 are isolated. In this case, there exists no connecting member for connecting the die pad 201 to the outer frame 200.

Subsequently, although not shown, a die bonding step and a wire bonding step are carried out. In the die bonding step, a semiconductor chip 260 is mounted on the die pad 201 in each chip mounting region **Rtp** of the leadframe **LF2** that is placed onto the 20 encapsulation sheet 250, and in the wire bonding step, pad electrodes of the semiconductor chip 260 and the bonding pads 204a of the land portions 204 are connected to each other with metal wirings 270 each serving as a connecting member.

Then, as in the step shown in FIG. 5 in the first embodiment, the leadframe **LF2** is set in an encapsulation die that includes an upper die member 180a and a lower die member 25 180b and has a die cavity therebetween. Specifically, the leadframe **LF2** is set in the

encapsulation die so that the semiconductor chip **260**, the metal wirings **270** and so on are located within the die cavity, and the die cavity is filled with plastic encapsulant with the upper and lower die members **180a** and **180b** pressed toward each other.

After the step of carrying out plastic encapsulation has been completed, the 5 encapsulation sheet **250** is removed from the leadframe **LF2** and plastic encapsulant, and then a large number of plastic-encapsulated semiconductor devices provided on the leadframe **LF2** are each cut out, thus obtaining the plastic-encapsulated semiconductor devices each having the structure shown in FIGS. **10A** and **10B**. It is to be noted that in the cross section shown in FIG. **10A**, the transverse size of the right half is scaled down so as to correspond to that of 10 the left half.

As shown in FIGS. **10A** and **10B**, each land electrode **204b**, which is the lowermost part of each land portion **204** of the leadframe **LF2**, the lowermost part of the main body of the die pad **201**, the lowermost part of each heat dissipating terminal **201b** of the die pad **201**, and the lowermost part of each reinforcing land **203** are protruded downward from plastic 15 encapsulant **290**. In particular, it can be seen that a plurality of rows (three or more rows) of the heat dissipating terminals **201b** and land electrodes **204b** are arranged at fixed pitch intervals (spacing) **P2** in the longitudinal and transverse directions in FIG. **10B**, and the heat dissipating terminals **201b** and the land electrodes **204b** are arranged also in the vicinity of each corner.

When the plastic-encapsulated semiconductor device is packaged on the 20 motherboard afterward, it is sufficient to connect the land electrodes **204b** and heat dissipating terminals **201b** to the associated electrodes of the motherboard by a mass reflow soldering process, and in this case, it is unnecessary to connect the main body of the die pad **201** to the motherboard.

In the plastic-encapsulated semiconductor device of the present embodiment, there 25

exist no suspension leads that have conventionally been provided, and furthermore, the connections 205, which are narrower and thinner than the land portions 204, are provided between the die pad 201 and the land portions 204 of the leads 202, between the land portions 204 associated with each other in each lead 202, and between the land portions 204 and the outer frame 200. Therefore, in the step shown in FIGS. 9A and 9B, the leads 202 can be easily cut between the land portions 204 associated with each other in each lead 202 and between the land portions 204 and the outer frame 200 with the semiconductor chip 260 mounted on the leadframe LF2, and the wire bonding step and/or the plastic encapsulation step can be carried out with no connecting member provided between the die pad 201 and the outer frame 200.

Accordingly, the fabricators can be saved from having to carry out etching, stamping or the like for the formation of the suspension leads, and since the heat dissipating terminals 201b are provided as already described above, the land electrodes 204b can be provided at a density higher than that at which the land electrodes 104a are provided in the first embodiment.

Besides, since the die pad 201 is provided with the heat dissipating terminals 201b, the heat dissipating terminals 201b and land electrodes 204b can be connected to, for example, the electrodes of the motherboard by a mass reflow soldering process in the step of packaging the plastic-encapsulated semiconductor device. That is, when the plastic-encapsulated semiconductor device is packaged, it is unnecessary to connect the main body of the die pad 201 to the motherboard for heat dissipation; therefore, the occurrence of connection failure can be reduced, and the packaging can be easily completed while the heat dissipating property of the plastic-encapsulated semiconductor device is being maintained at a high level.

The spacing between the heat dissipating terminals 201b and the land electrodes 204b, and the spacing between the land electrodes 204b do not necessarily have to be fixed,

and even if they are arranged at fixed pitch intervals, the pitch in the longitudinal direction in FIG. 10B may be different from the pitch in the transverse direction in FIG. 10B. However, it is particularly preferable that the heat dissipating terminals 201b and the land portions 204 are substantially identical in shape in plan view, and that the connections 205 between the 5 heat dissipating terminals 201b and the land portions 204 and the connections 205 between the land portions 204 associated with each other in each lead 202 are substantially identical in shape in plan view. In such a case, since the heat dissipating terminals 201b and the land electrodes 204b are provided at fixed pitch intervals, the mass reflow soldering process can be easily carried out, thus easily carrying out the packaging of the plastic-encapsulated 10 semiconductor device.

<Other Embodiments>

FIGS. 11A and 11B are a plan view of a leadframe (leadframe LF3) according to a modified example of the second embodiment of the present invention, and a cross-sectional 15 view taken along the line XIB-XIB shown in FIG. 11A, respectively. Actually, in the leadframe LF3, regions thereof on which a large number of semiconductor chips are to be mounted are laid out continuously in a grid pattern; however, FIG. 11A only shows a part of the leadframe LF3, i.e., a region thereof on which a single semiconductor chip is to be mounted. The leadframe LF3 is obtained by, for example, etching or stamping a copper 20 alloy plate.

As shown in FIGS. 11A and 11B, the leadframe LF3 according to the modified example includes: a rectangular outer frame 300 including four sides that surround a chip mounting region Rtp; a die pad 301 which is provided at the center of the chip mounting region Rtp and on which a semiconductor chip is to be mounted; leads 302 extending from 25 the outer frame 300 to connect with the die pad 301; reinforcing lands 303; and heat

dissipating terminals **301b** that are provided at the peripheral section of the die pad **301** and are connected to the lead **302**.

The leads **302** of the modified example each include land portions **304** and connections **305** which are alternately arranged. The land portions **304** each have a width of 5 20 μm to 120 μm , for example, and a thickness of 20 μm to 120 μm , for example, and the connections **305** each have a width of 15 μm to 100 μm , for example, and a thickness of 15 μm to 100 μm , for example. That is, each land portion **304** is wider and thicker than each connection **305**. The upper surface of each land portion **304** functions as a bonding pad **304a** to be connected with a metal wiring. In the step of packaging a semiconductor chip on 10 the leadframe **LF3**, plastic encapsulation is carried out with the lower surface of each land portion **304** fixed onto an encapsulation sheet having an adhesive layer, and after the plastic encapsulation has been completed, the lowermost part of each land portion **304** is allowed to function as a land electrode **304b** that is protruded downward from the bottom surface of the plastic encapsulant. Via the connections **305**, the outer frame **300** and the land portions **304** 15 are connected to each other, the land portions **304** associated with each other in each lead **302** are connected to each other, and the land portions **304** and the heat dissipating terminals **301b** of the die pad **301** are connected to each other. Each connection **305** is allowed to be devoid of its lower part by a pressing process utilizing a die or by an etching process, and is embedded within the plastic encapsulant in the step of packaging a semiconductor chip on 20 the leadframe **LF3**. The connections **305** are each continuous with the upper part of each land portion **304**, and the upper surface of each connection **305** and that of each land portion **304** constitute a common plane.

In the leadframe **LF3** of the modified example, there exist leads each functioning as a suspension lead during the step of carrying out plastic encapsulation. To be more specific, 25 in the leadframe **LF3** of the modified example, unlike the leadframe **LF2** of the second

embodiment, there are provided suspension leads 309 that are directly connected to the die pad 301 in the vicinities of the corners thereof. Therefore, unlike the second embodiment, there exists no lead having one end connected to one side of the outer frame 300 and the other end connected to the other lead extending from the other side of the outer frame 300 adjacent to the one side thereof. In the leadframe LF3, each lead 302x (or 302y), provided in the vicinity of a corner of the outer frame 300 and connected to one side of the outer frame 300, is connected with another lead 302x (or 302y) extending from the one side of the outer frame 300.

Also in the leadframe LF3 of the modified example, in the vicinities of the corners of the outer frame 300, there are provided the reinforcing lands 303 each having an area (e.g., a diameter of 300 μ m to 1500 μ m) considerably larger than that of each land portion 304.

In the modified example, like the second embodiment, the heat dissipating property can be improved and the land electrodes 304b can be provided at a high density due to the existence of the heat dissipating terminals 301b. However, since the suspension leads 309 are provided in the modified example, the density at which the land electrodes 304b are provided in the modified example is lower than that at which the land electrodes 204b are provided in the second embodiment; on the other hand, the die pad 301 can be more stably held during the step of cutting the leads 302 in the modified example than in the second embodiment.

In the first embodiment, second embodiment and modified example thereof, the connections may be provided between the land portions of the adjacent leads. In such a case, the land portions are connected in a lattice pattern in both of the longitudinal and transverse directions, and therefore, the shape of the leadframe can be more stably kept until the leads are cut.

The inventive leadframe and plastic-encapsulated semiconductor device are

applicable as electronic components to be provided in personal computers, household electrical appliances and communications equipment.